

## A Last Glacial Maximum experiment using MIROC-ES2L earth system model in comparison with ice core and the other paleo-proxy data

\*Rumi Ohgaito<sup>1</sup>, Tomohiro Hajima<sup>1</sup>, Akitomo Yamamoto<sup>1</sup>, Hiroaki Tatebe<sup>1</sup>, Michio Kawamiya<sup>1</sup>, Ayako Abe-Ouchi<sup>2,1</sup>

1. Japan Agency for Marine-Earth Science and Technology, 2. AORI, Univ. Tokyo

We are performing numerical experiments targeting distinctive time period of the past, Last Glacial Maximum (LGM, 21,000 years before present), using MIROC-ES2L. MIROC-ES2L is a newly developed earth system model (ESM) (Hajima et al. in prep.) including atmosphere, ocean, land, and ocean and land biogeochemical cycles in order to contribute Coupled Model Intercomparison Project phase 6 and Intergovernmental Panel on Climate Change 6<sup>th</sup> assessment report.

Testing climate models using paleoclimate experiments is an irreplaceable opportunity on evaluation of models to simulate climate change significantly different from the present day. In this presentation, we describe how we simulate the LGM experiment, compare with paleo-proxy data and discuss which component contributed for the realization of the LGM climate.

Following protocol of Paleoclimate Modelling Intercomparison Project phase 4 (Kageyama et al. 2017), we are performing a LGM experiment. Because the LGM condition is significantly different from the present day, long spin-up is essential. Hence, before the model development is finalized, we started spin-up using the physical core (Atmosphere-Ocean coupled general circulation model) of MIROC-ES2L. Firstly, an experiment is branched from pre-industrial control (PI) experiment and the greenhouse gas levels are reduced to the LGM values. After integration for 2640 model years, land-sea mask and ice sheets, altitude, river path, orbit of the earth, salinity of ocean, and an erodibility map (concerning dust) of the LGM conditions are applied step by step and the total spin-up reached 6760 model years. Since MIROC-ES2L is ready during this procedure, the initial conditions at the 6760th model year of the spin-up experiment are used to initiate LGM experiment using MIROC-ES2L. In this conversion procedure, the initial conditions for land and ocean biogeochemical cycles were prepared respectively using offline modules to obtain quasi-stabilized states. Global mean temperature drawdown of the last 60 year climatology after 540 years integration with the ESM is -4.4 degree Celsius. Borehole thermometry suggested the cooling over the Eastern Antarctica at LGM was -7 to -10 degree Celsius (Stenni et al. 2010, Uemura et al. 2012). The modelled temperature anomaly is about -6.0 degree Celsius, which suggests weaker cooling compared to the ice core data. For the central Greenland, borehole thermometry suggested -21 to -25 degree Celsius (Cuffey et al. 1995, Johnsen et al. 1995, Dahl-Jensen et al. 1998), whereas the LGM experiment resulted -11.1 degree Celsius. This large discrepancy would be attributed to realization of ocean thermohaline state in the model experiment. The modelled peak value of the Atlantic Meridional Overturning Circulation (AMOC) is 21.0 Sverdrup for LGM and 15.3 Sverdrup for PI. On the other hand, AMOC is thought to be weaker than the present day from paleo proxy data (Lynch-Stieglitz et al. 2007, Hesse et al. 2011). We continue the experiment and analyze which component contributes global cooling and the cooling over the polar regions.

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